

## DETAILED DESCRIPTION OF EMBODIMENT

**[0027]** Referring to FIG. 1, there is shown a front view of an apparatus 10 incorporating features of an example embodiment. Although the features will be described with reference to the example embodiments shown in the drawings, it should be understood that features can be embodied in many alternate forms of embodiments. In addition, any suitable size, shape or type of elements or materials could be used.

**[0028]** The apparatus 10 may be a hand-held portable apparatus, such as a communications device which includes a telephone application for example. In the example shown the apparatus 10 is a smartphone which includes a camera and a camera application. The apparatus 10 may additionally or alternatively comprise an Internet browser application, a video recorder application, a music player and recorder application, an email application, a navigation application, a gaming application, and/or any other suitable electronic device application. In an alternate example embodiment the apparatus might not be a smartphone. For example, the apparatus might be a gaming device or handset, or video recorder for example.

**[0029]** Referring also to FIGS. 2-3, apparatus 10, in this example embodiment, comprises a housing 12, a display module 14 which includes a touchscreen function, a receiver 16, a transmitter 18, a controller 20, a rechargeable battery 26 and a camera 30. However, all of these features are not necessary to implement the features described below. The receiver and the transmitter may be provided in the form of a transceiver for example. The electronic circuitry inside the housing 12 may comprise at least one printed wiring board (PWB) 21 having components such as the controller 20 thereon. The controller 20 may include at least one processor 22, at least one memory 24, and software 28. The receiver 16 and transmitter 18 form a primary communications system to allow the apparatus 10 to communicate with a wireless telephone system, such as a mobile telephone base station for example.

**[0030]** In this example, the rear side 13 of the apparatus 10 includes the camera 30, an LED 34, and a flash system 36. The LED 34 and the flash system 36 are provided for the camera 30. The camera 30, the LED 34 and the flash system 36 are connected to the controller 20 such that the controller 20 may control their operation. In an alternate example embodiment the rear side may comprise more than one camera, and/or the front side could comprise more than one camera. The apparatus 10 includes a sound transducer provided as a microphone 38 and a sound transducer provided as a loudspeaker 40. In an alternate example the apparatus may comprise more than one microphone and/or more than one loudspeaker.

**[0031]** Referring also to FIG. 4, the display module 14, in addition to the touchscreen function, forms an earpiece speaker 70 comprising a vibrating element 72 and a display element 74. The display element 74, in this example, includes the display module 14 that is a touchscreen display in this example; which functions as both a display screen and as a user input. The display element 74 may comprise a touch input device (TID) as the display module 14, such as a capacitive sensor for example. However, features described herein may be used in a display which does not have a touch, user input feature. Alternatively, another example may comprise an apparatus which has touchpad or touch-panel which is not part of an electronic display screen.

**[0032]** In this example the vibrating element 72 comprises a piezoelectric member 75. The piezoelectric member 75 may

be electrically connected to the printed circuit board 21. The display element 74 is an electronic display. A member 78 connects the piezoelectric member 75 to the back side of the display element 74. In one example embodiment the piezoelectric member 75 is controllably flexed or vibrated by electricity supplied from the printed circuit board 21. This causes the piezoelectric member 75 to move the electronic display 74 in and out as illustrated by arrow 634 to generate sound waves from the front of the electronic display 74 (and/or the covering window).

**[0033]** Referring also to FIG. 5, in this example the apparatus comprises only one piezoelectric member 75 connected to the back side of the display element 74 at the top end 15 of the display 14. The piezoelectric member 75 is spaced from the bottom end 17 of the display 14. The piezo actuator may be directly coupled to the display module might not be directly coupled to the display module. The earpiece speaker in a broader definition may comprise additional element(s). For example, an earpiece speaker may have a plate under the display module where the piezo may be used to actuate the plate so that the plate could move/vibrate the display in a z-direction (634). The piezo or electromagnetic actuator (EMA) may be placed under the electronic display or directly under the front window. Both types of embodiments work well depending on the display technology. In an embodiment where the display is a LCD display, it is better if the piezo or EMA is connected to the front glass window. However, in an embodiment where the display is an OLED display, it may be better to place the actuator directly under the display, such as in the upper half or third of the display for example. For when the display is an OLED display, the low frequency output may be better if the actuator is placed there. This is because the display package is stiff in this area, going closer to the center point of the display than at the edge of the display. The display can flex better when the actuator pushes at this area. Therefore, the low frequency output may be better. If the actuator is closer to the upper edge of the device it may be hard for the actuator to bend the display, but this may still be appropriate for when the display is an LCD display. When the display is an LCD display, the overall stiffness of the whole display package may be lower than when an OLED is laminated together with a glass window. That is why, when the display is an LCD display, the actuator can be added close to the edge and it still provides good low frequency output. If this were done when the display is an OLED display, the low frequency output might be quite low. When the display is an OLED display the actuator may be placed closest to the center of the device. A front window 80 may be provided as the front face of the display element 74. In an alternate example embodiment, rather than a piezoelectric member, the vibrating element may comprise vibrating of the display with a dynamic actuator such as speaker or vibra. Thus, features as described herein are not limited to using a piezoelectric actuator.

**[0034]** Features as described herein may fundamentally utilize implementation of "Audio Display" or "panel speaker" concept which has been developed by Nokia Corporation. In the Audio Display concept, generally, at least one piezo actuator may be suitably coupled to the display module for sound generation so that the display module can be used as a conventional display, but further for sound generation and perhaps tactile feedback. In alternative embodiments of Audio Display integrations, the piezo actuator may be coupled to the display window 80 (at the front of the display module 14) for sound generation. There are various ways of reproducing